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MODELS OF BLAST FURNACES FOR SMELTING IRON

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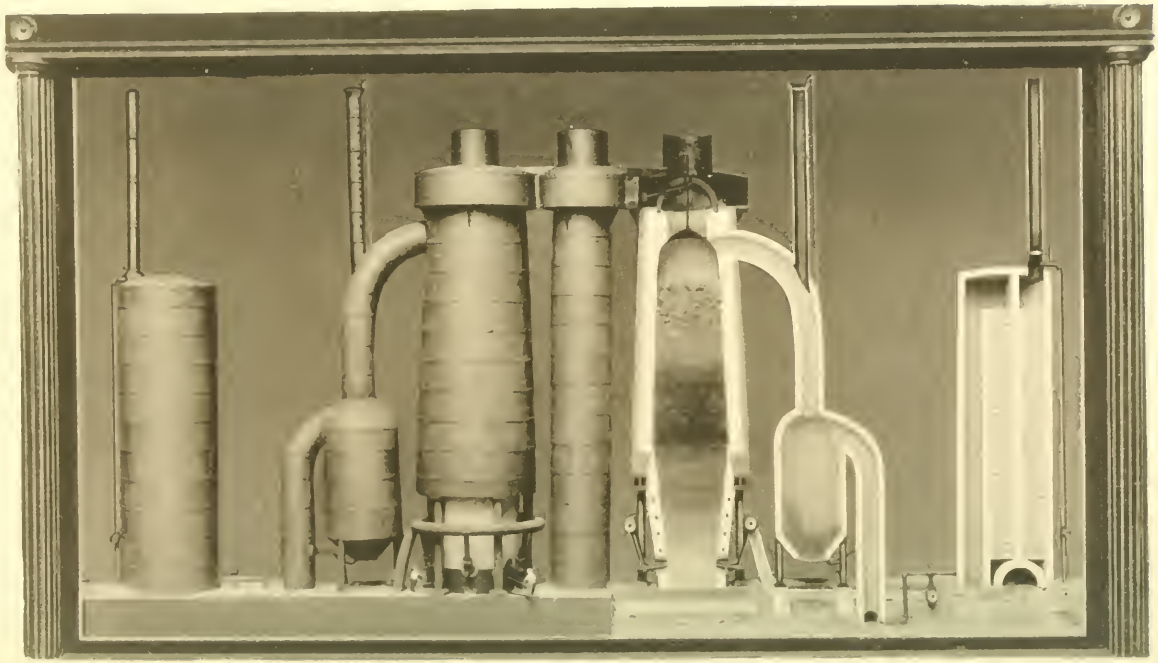

MODEL OF MODERN IRON BLAST FURNACE.

FIELD MUSEUM OF NATURAL HISTORY
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Models of Blast Furnaces for Smelting Iron

Three models represent the hot blast furnace of today, the cold blast furnace of seventy years ago and the small forge in which iron was smelted one hundred and fifty years ago.

I. THE MODERN IRON BLAST FURNACE. Practically all the iron in use is extracted from its ore in blast furnaces, one of which is represented in miniature by the model in the right half of the case. It is called a blast furnace because its operation is maintained by a blast of air blown in from below. Its product is pig or cast iron which, remelted and shaped in molds, forms our cast iron objects. All steel and wrought iron is refined from this pig iron. The process of smelting iron ore is based on simple principles although the practice of smelting is decidedly complex in detail. A mixture of ore, limestone and fuel is fed in at the top of a tall furnace (the furnace reproduced is sixty-five feet high). The fuel, coke prepared from soft coal, is made to burn with great intensity by a blast of hot air blown in from below. Hot gases formed by the incomplete combustion of the coke attack the ore which is a combination of iron and oxygen and take away its oxygen. This leaves the iron behind in a free state. Lower in the furnace this iron absorbs carbon from contact with hot coke, melts and falls to the hearth below whence it is drawn off from time to time in molten condition. The earthy impurities of the ore and the ash of the coal combine with the lime-

stone and form a slag which melts and runs from the furnace. The furnace runs continuously day and night from the time it is blown in until it is necessary to shut down for repairs. As the charge wastes away below it is replenished by additions of ore, limestone and fuel from above.

The model represents in some detail the furnace in which the smelting is accomplished and some of its accessories. At the center of the model is a circular tower which houses an elevator by which materials to be fed to the furnace are lifted to the top. At the left of the elevator is a blast furnace and some of its accessories. At the right the furnace and accessories are repeated in section, that is cut open to show the inside.

THE FURNACE or STACK is a tall structure of brick enclosing a central shaft lined with the best quality of fire-brick and cased on the outside with boiler iron. This furnace is sixty-five feet high and sixteen feet wide at its widest part. Many furnaces are larger than this. The disk-like structure which rests on top of the furnace is a circular room of boiler iron which encloses the CHARGING PLATFORM from which the furnace is fed. The material fed to the furnace is the CHARGE. The charge is a mixture in carefully proportioned quantities of ore, flux and fuel. THE ORE is a combination of iron and oxygen and is the source of the iron which is the product of the furnace. THE FLUX is limestone. This combines with any infusible matter which may form in the furnace, causes it to melt and washes it from the furnace in the form of slag. It also prevents waste of the iron of the ore and serves other useful purposes. THE FUEL is generally coke although some few furnaces use charcoal. The fuel provides the necessary heat and also the reducing gases which free the iron from the ore.

The charging platform is connected with the top of the elevator tower by a bridge. Over this bridge the charge of ore, coke and limestone is wheeled in barrows or small cars. The top or THROAT of the furnace opens at the center of the charging floor. This opening is ordinarily closed by the BELL, a conical valve opening downwards. The barrows or cars which bring the charge are dumped on top of the bell. The bell is then momentarily depressed and the charge falls into the furnace. When the bell is opened the furnace fumes come through to the charging floor so a short smokestack is provided by which they may escape. The bell is closed nearly all the time and the products of combustion cannot escape through the top. They then pass through an opening in the furnace wall immediately below the bell to the DOWN-COMER, a large brick-lined pipe which passes downward outside the furnace. Through the down-comer the gases pass to underground conduits which conduct them to the places where they are used. THE GAS BLOW-OFF is a smokestack connected with the down-comer and closed at the top by a valve. By opening this valve any surplus gas may be allowed to escape. The gases from the furnace carry with them dust from the ore and fuel in the furnace. Much of this dust settles in the DUST-CATCHER, a chamber connected with the down-comer. From time to time the dust is drawn off through a gate in the bottom of the dust-catcher, and after suitable treatment, fed back to the furnace. The shaft of the furnace gradually widens downward for more than half its length to the place where it is widest which is called the BOSH. From the bosh it narrows gradually to the hearth at the bottom. This tapering part from the bosh down to the hearth is called the BOSHES. In this area the heat is so intense that the fire-brick walls would either melt or be

eaten away by slag if they were not protected. Protection is afforded by water cooling. This is provided by water which constantly runs through a number of metal pipes imbedded in the masonry of the boshes.

About five feet above the base of the furnace and immediately below the boshes are six TUYERES. These are metal nozzles through which a blast of hot air continuously enters the furnace. The tuyeres draw their supply of hot air from the BUSTLE PIPE, a large brick-lined pipe which encircles the furnace slightly above the tuyeres. Below the tuyeres is the CRUCIBLE or HEARTH which is that part of the furnace in which the molten iron accumulates until there is sufficient to tap. The furnace is kept filled with a carefully proportioned mixture of ore, coke and limestone to a point near the top called the STOCK LINE. The blast of hot air which enters through the tuyeres burns the coke and in that part of the furnace an intense heat is generated. The tall column of charge which lies between this zone of combustion and the stock line above rapidly absorbs heat from the rising gases, so that the charge which is at an intense white heat near the tuyeres is below a red heat at the top.

The section of the furnace shows the charge white hot below, passing through the several stages of yellow, orange and red heats to black at the top. When coke or coal is burned in an ordinary stove combustion is fairly complete and the principal product is an incombustible gas called carbon di-oxide. When a very deep bed of fuel is burned, the combustion is not complete and the product is a gas, carbon mon-oxide, which can itself be burned. As the charge of the furnace forms a bed over fifty feet deep the gas from burning the coke of the charge in the hot blast of air at the tuyeres is this combustible gas, carbon mon-oxide.

MODEL OF COLD BLAST IRON BLAST FURNACE.

This coming in contact with hot iron ore abstracts its oxygen and frees the iron. This iron is set free in a comparatively pure form which melts with difficulty. Even in the intense heat of the hotter part of the furnace it would only become pasty. In contact with the hot coke each particle of iron absorbs a small quantity of carbon which gives it the composition of cast iron which melts readily at furnace temperatures. The iron then melts and drops to the bottom of the furnace where it collects in a molten slate in the crucible. When a sufficient quantity of iron has collected it is withdrawn through the TAP HOLE. This is a small round hole at the base of the furnace connecting with a shallow groove or channel in the floor in front. This tap hole is closed by a stopping of fire clay or other refractory material. When the time comes to tap the iron, the clay stopping is broken out and the iron allowed to run into the channel which may conduct it to a pig bed, not shown in the model, where it is cast in sand molds and takes the form of rough blocks called PIGS. When a steel works is connected with the furnace plant, the molten iron as tapped is conveyed directly to the mills for conversion to steel.

The blast furnace runs continuously and all that enters must escape in a gaseous or liquid state as there is no provision for removing solids. Earthy matters not easily fusible are present in the ores and in the ash of the fuel. Limestone from the furnace charge combines with these and under the influence of heat forms a fusible waste product, the SLAG or CINDER. This floats on the molten iron in the crucible and runs off through the SLAG EYE. This is a small opening a little below the tuyeres and to the right which a man with an iron rod is cleaning. The blast of air is provided by BLOWING ENGINES which do not appear

in the model. These are large air-compressors driven either by gas engines or by steam engines which take their steam from gas-fired boilers. These engines or boilers use the furnace gases which are drawn from the top of the furnace through the down-comer and led to the engine room by underground conduits. Other conduits lead the compressed air for the blast from the blowing engines to the STOVES where it is heated. The stoves are the tall structures which appear at the outer edges of the model. They are built of fire-brick and cased with boiler iron. They are so designed that the inside consists of numbers of narrow fire-brick passages. Each furnace is provided with two or more stoves although only one appears in the model. A pipe connects the stove with gas ducts which are fed from the down-comer of the furnace. Gas is burned in the stove until all the fire-brick passageways become hot. Then the gas is shut off and air from the blowing engine enters at the top. This air becomes heated in the passage and emerges below into underground ducts which conduct it to the bustle pipe of the furnace. Stoves are intermittent in operation, one supplies air to the furnace while another is being heated. The output of the furnace is pig iron, slag and gas. The gas is consumed in the stoves and in operating the blowing engines although there is sometimes a surplus which may be used for other purposes. The slag is mostly a waste product although some is used in the manufacture of portland cement and in other ways. The principal product is pig iron. This iron contains small quantities of various impurities, which have an important effect in its properties. From long contact with hot coke in the furnace it has absorbed a quantity of carbon which has made it fusible and suited for the manufacture of cast iron articles. Most pig iron is refined to steel. Refining removes impurities and

makes the iron stronger, less brittle, and more difficult to melt. When practically all the carbon is removed the product is wrought iron or mild steel according to the method of refining employed. When the refined product contains certain definite amounts of carbon it is tool steel or other high grade steel. The output of a blast furnace is large. Some furnaces have yielded over 900 tons of iron per day. The furnace represented by the model yields 300 tons daily.

EARLIER TYPES OF FURNACE

Two models in the left half of the case represent two obsolete types of iron smelting furnaces. One was in use one hundred and fifty years ago, the other sixty years ago and even later. They illustrate the immense advance in the art of iron smelting during the past two hundred years and call attention to the relatively recent introduction of the modern furnace with its large capacity and moderate cost of operation. Before the time of the Catalian forge, the earliest of those shown, more primitive devices were employed and the progress from this forge to the modern furnace was marked by a number of furnace types other than those represented by these models.

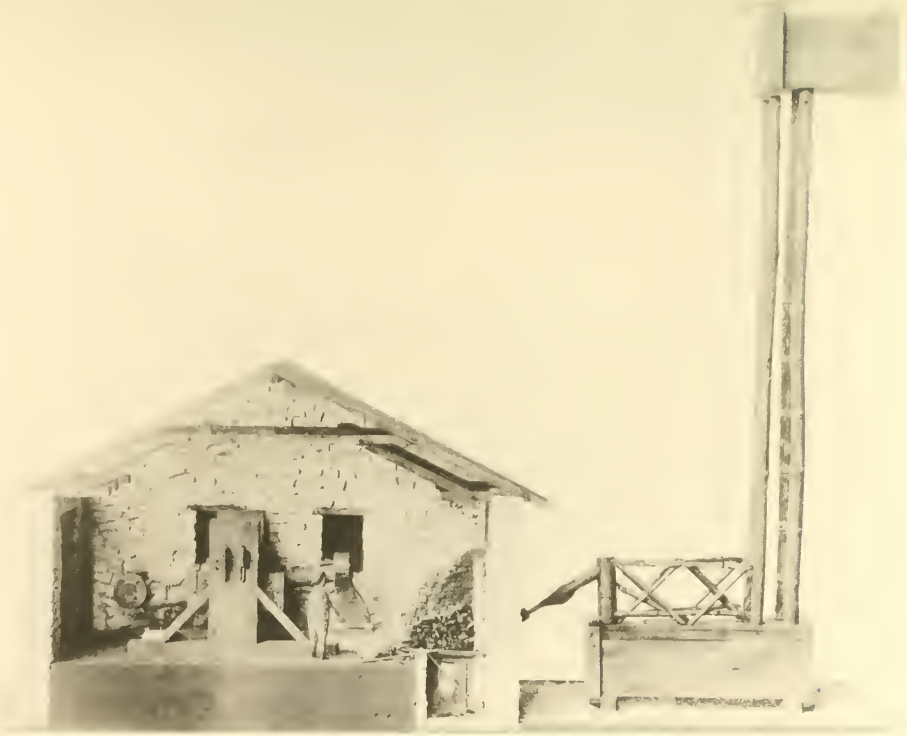
II. THE COLD BLAST IRON SMELTING FURNACE

The central model of the three represents a cold blast iron smelting furnace modelled on the same scale as the hot blast furnace to the right. It is called a cold blast furnace because the blast of air which keeps it in operation is not heated. This furnace was the immediate predecessor of the hot blast furnace of today which has completely superseded it. It was in general use in this country at the time of the civil war and for

some years after. It operated on the same principle as the modern furnace, but as it did not have the hot blast, did not utilize the furnace gases and lacked other refinements, its efficiency and capacity were low. Its most noticeable features were the massive construction, the large flame at the top and the primitive character of the equipment.

The massive pyramidal structure near the center of the model is the furnace. It is built of limestone and encloses a small central shaft similar in outline to that of a modern furnace. It is built at the foot of a cliff so that the charge may be fed at the top without hoisting. The top of the furnace is connected with the top of the cliff by a bridge over which the charge of ore, charcoal and limestone is wheeled in barrows. The top is enclosed in an iron hood which is provided with a smokestack so that the charging platform may be sufficiently free from gases to permit men to work there. The top is open and the gases generated in the furnace escape and burning continuously form a large flame visible for miles. Iron and slag form as in the modern furnace and are drawn off in a similar manner although the provisions for this are more complex than they are in modern furnaces. At the right of the model is the wooden blowing engine called the TUBS. At the extreme right is the water wheel which drives the blowing engine. This engine consists of two wooden upright cylinders, the tubs, provided with wooden pistons and appropriate valves. The tubs deliver their air to a third tub above which acts as a receiver. From this receiver an underground conduit takes the air direct to the tuyeres which feed it to the furnace. The output is low. Such a furnace as the model represents might yield thirty tons of pig iron a day.

III. THE CATALIAN FORGE. The model at the left represents the Catalian forge which was in



MODEL OF CATALIAN FORGE.

general use in Europe during the eighteenth century and in this country at the time of the Revolution and for some years after. Forges of the same general type have been used among peoples of the more primitive cultures in relatively recent times and they may have persisted in places to the present day. The forge is small, not much larger than an ordinary blacksmith's forge. The model is on a scale of one inch to the foot. At the left is the large hammer which finishes the iron. In the center is the hearth in which the ore is reduced and at the right is the trompe in which air is compressed to provide the air blast which urges the fire on the hearth.

THE TROMPE which provides the air blast for the hearth is a simple device by which falling water is made to trap air and deliver it under pressure. It consists of an upright hollow log fed with water from a flume above and connected below with an air tight tank. A valve at the top controlled through a lever and hanging cord admits and shuts off the water. Near the top of the log are a number of perforations. Water falling freely draws air in through these perforations and delivers it to the tank below under a pressure dependent on the height of the log. The water escapes through a gate near the bottom of the tank and the air passes through a pipe at the top to a conduit which conducts it to the hearth.

THE HEARTH which appears in the center of the model is much like a blacksmith's hearth with a blast from the tromp instead of from bellows. On this hearth a charcoal fire is built and urged to intensity by the air blast which enters through a nozzle called the TUYERE which passes through the rear wall. This fire is fed by a mixture of iron ore and charcoal. Under the influence of heat the ore, which is a combination of iron and oxygen, gives up its oxygen

to the charcoal and metallic iron appears in the form of small granules. The heat of the forge is not sufficient to melt the iron but does cause it to become pasty. These pasty grains of iron settle to the bottom where they cohere and form a spongy mass of iron called the LOUPE. The pores of this iron sponge are filled with CINDER, a liquid or pasty mass in which the impurities of the ore and the ash of the charcoal are combined with unreduced oxides of iron from the ore. After the hearth has been in operation for some six hours the loupe has grown to the proper size for the next treatment. The smelting is then interrupted and the loupe removed. A new fire is built and smelting is resumed.

THE HAMMER. This large hammer shown at the left of the model is driven by a water wheel concealed by the rear wall of the building. The shaft of the water wheel passes through the wall and is armed with teeth or cams which act on the haft of the hammer lifting it and letting it fall. The hot loupe is placed under this hammer, which squeezes out the cinder and compacts the iron into a solid BLOOM which is merchantable. This forge can produce either wrought iron or steel as the details of the operation are varied. Cast iron never forms except by accident. The output of the forge is of excellent quality but the quantity is very small say three hundred pounds of iron each six hours.

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These models are exhibited on the second floor of the Museum in an alcove in Frederick J. V. Skiff Hall.

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